Practitioner's Docket No. AP9610

CHAPTER II

TRANSMITTAL LETTER
TO THE UNITED STATES ELECTED OFFICE (EO/US)

(ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

PCT/EP00/02741	29/March/2000	3/April/1999
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement
TITLE OF INVENTION

Martin GRIESSER
APPLICANT(S)

Box PCT
Commissioner for Patents
Washington D.C. 20231
ATTENTION: EO/US

NOTE: *To avoid abandonment of the application, the applicant shall furnish to the USPTO, not later than 20 months from the priority date: (1) a copy of the international application, unless it has been previously communicated by the International Bureau or unless it was originally filed in the USPTO; and (2) the basic national fee (see 37 C.F.R. § 1.492(a)). The 30-month time limit may not be extended. 37 C.F.R. § 1.495.*

WARNING: *Where the items are those which can be submitted to complete the entry of the international application into the*

CERTIFICATION UNDER 37 C.F.R. 1.10*
*(Express Mail label number is **mandatory**.)*
(Express Mail certification is optional.)

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date 10-3-01, in an envelope as "Express Mail Post Office to Addressee," Mailing Label Number EL 862 870 437 US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Joyce Krumpe
(type or print name of person mailing paper)

Joyce Krumpe
Signature of person mailing paper

WARNING: *Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

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*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. §1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. §1.8.

NOTE: *Documents and fees must be clearly identified as a submission to enter the national state under 35 USC 371 otherwise the submission will be considered as being made under 35 USC 111. 37 C.F.R. § 1.494(f).*

1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. 371:

   a. [X] This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).

   b. [X] The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

09/937986
410 Rec'd PCT/PTO 03 OCT 2001

2.Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULA-TIONS
[ ]*	TOTAL CLAIMS	19 - 20 =		x $ 18.00 =	$
	INDEPENDENT CLAIMS	2 - 3 =		x $ 78.00 =	
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + $260.00				
BASIC FEE**	[ ] U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: [ ] and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(2) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 CFR 1.492(a)(4)) .... $96.00 [ ] and the above requirements are not met (37 CFR 1.492(a)(1)) .... $670.00 [X] U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: [ ] has been paid (37 CFR 1.492(a)(2)) .... $760.00 [ ] has not been paid (37 CFR 1.492(a)(3)) .... $970.00 [X] where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) $890.00				
	Total of above Calculations				= 890.00
SMALL ENTITY	Reduction by ½ for filing by small entity, if applicable. Affidavit must be filed. (note 37 CFR 1.9, 1.27, 1.28)				-
	Subtotal				890.00
	Total National Fee				$ 890.00
	Fee for recording the enclosed assignment document $40.00 (37 CFR 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				
TOTAL	Total Fees enclosed				$ 890.00

*See attached Preliminary Amendment Reducing the Number of Claims.

i. [ ] A check in the amount of ___________ to cover the above fees is enclosed.

ii. [X] Please charge Account No. 18-0013 in the amount of $ 890.00 .

A duplicate copy of this sheet is enclosed.

***WARNING:* *"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: * * * (2) the basic national fee (see § 1.492(a)). The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).*

WARNING: *If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.*

3. [X] A copy of the International application as filed (35 U.S.C. 371(c)(2)):

NOTE: *Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35-36. See item 14c below.*

a. [X] is transmitted herewith.

b. [ ] is not required, as the application was filed with the United States Receiving Office.

c. [ ] has been transmitted

i. [ ] by the International Bureau.
Date of mailing of the application (from form PCT/IB/308): __________.

ii. [ ] by applicant on _______.
Date

4. [X] A translation of the International application into the English language (35 U.S.C. 371(c)(2)):

a. [X] is transmitted herewith.

b. [ ] is not required as the application was filed in English.

c. [ ] was previously transmitted by applicant on _________________.
Date

d. [ ] will follow.

5. [ ] Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. 371(c)(3)):

09/937986
410 Rec'd PCT/PTO 03 OCT 2001

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

a. [ ] are transmitted herewith.
b. [ ] have been transmitted
  i. [ ] by the International Bureau.
  Date of mailing of the amendment (from form PCT/IB/308): __________.
  ii. [ ] by applicant on _______.
  Date
c. [ ] have not been transmitted as
  i. [ ] applicant chose not to make amendments under PCT Article 19.
  Date of mailing of Search Report (from form PCT/ISA/210): __________.
  ii. [ ] the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. [ ] A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. 371(c)(3)):
a. [ ] is transmitted herewith.
b. [ ] is not required as the amendments were made in the English language.
c. [ ] has not been transmitted for reasons indicated at point 5(c) above.

7. [x] A copy of the international examination report (PCT/IPEA/409)
[x] is transmitted herewith.
[ ] is not required as the application was filed with the United States Receiving Office.

8. [x] Annex(es) to the international preliminary examination report
a. [x] is/are transmitted herewith.
b. [ ] is/are not required as the application was filed with the United States Receiving Office.

9. [ ] A translation of the annexes to the international preliminary examination report
a. [ ] is transmitted herewith.
b. [ ] is not required as the annexes are in the English language.

10. [X] An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115
a. [ ] was previously submitted by applicant on ____________.
Date
b. [ ] is submitted herewith, and such oath or declaration
  i. [ ] is attached to the application.
  ii. [ ] identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. 1.70.

09/937986

410 Rec'd PCT/PTO 03 OCT 2001

iii. [X] will follow.

Other document(s) or information included:

11. [x] An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):
    a. [x] is transmitted herewith.
    b. [ ] has been transmitted by the International Bureau.
    Date of mailing (from form PCT/IB/308): ________________.
    c. [ ] is not required, as the application was searched by the United States International Searching Authority.
    d. [ ] will be transmitted promptly upon request.
    e. [ ] has been submitted by applicant on ________________.
    Date

12. [X] An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98:
    a. [X] is transmitted herewith.
    Also transmitted herewith is/are:
    [X] Form PTO-1449 (PTO/SB/08A and 08B).
    [X] Copies of citations listed.
    b. [ ] will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. 371(c).
    c. [ ] was previously submitted by applicant on ________________.
    Date

13. [ ] An assignment document is transmitted herewith for recording.

A separate [ ] "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or[ ] FORM PTO 1595 is also attached.

14. [X] Additional documents:
    a. [ ] Copy of request (PCT/RO/101)
    b. [x] International Publication No. WO00/59744
        i. [ ] Specification, claims and drawing
        ii. [x] Front page only
    c. [X] Preliminary amendment (37 C.F.R. § 1.121)
    d. [ ] Other

15. [X] The above checked items are being transmitted

09/937986
410 Rec'd PCT/PTO 03 OCT 2001

a. [X] before 30 months from any claimed priority date.
b. [ ] after 30 months.

16. [ ] Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on ____________, namely:

____
____
____

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: *"A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).*

NOTE: *"Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

[X] The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 18-0013.

[X] 37 C.F.R. 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box.*

[X] 37 C.F.R. 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: *Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.*

[X] 37 C.F.R. 1.17 (application processing fees)
[X] 37 C.F.R. 1.17(a)(1)-(5)(extension fees pursuant to § 1.136(a).
[ ] 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

NOTE: *Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of*

09/937986
410 Rec'd PCT/PTO 03 OCT 2001

allowance. 37 C.F.R § 1.311(b).

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

[X] 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).

SIGNATURE OF PRACTITIONER

Reg. No.: 33,373

Joseph V. Coppola, Sr.
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09/937986
410 Rec'd PCT/PTO 03 OCT 2001

AP9610

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Martin GRIESSER

Int'l Application No.: PCT/EP00/02741

Int'l Filing Date: 29/March/2000

Serial No.: Group Art Unit:

Filed: Herewith Examiner:

For: Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

Attorney Docket No.: AP9610 Paper No.

Box PCT
Commissioner for Patents
Washington, D.C. 20231
Attn: EO/US

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the application as follows prior to examination on the merits.

IN THE CLAIMS

Please cancel claims 1-24 and add the following new claims.

CERTIFICATE OF MAILING/TRANSMISSION (37 CFR 1.8(a))

I hereby certify that this correspondence is, on the date shown below, being:

☑ deposited with the United States Postal Service with sufficient postage as Express Mail, Post Office to Addressee, Mailing Label No.: EL 862 870 437 US, addressed to Box PCT, Commissioner for Patents, Washington, DC 20231

☐ transmitted by facsimile to the Patent and Trademark Office. to Examiner ____________ at ____________

Date: 10/3/01

Joyce Krumpe
Signature
Joyce Krumpe

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25. (New) Method for driving dynamics of a vehicle, comprising the steps of:

determining a loss of tire pressure by monitoring at least one of the vehicle parameters, vehicle speed, longitudinal acceleration, yaw rate, transverse acceleration, steering angle, curve characteristic quantity, wheel acceleration, wheel slip, wheel slip gradient, tire torsion,

modifying the response of one or more vehicle control systems based on the results of the determining step.

26. (New) Method as claimed in claim 25, wherein the modifying step further includes modifying the response of a vehicle brake control system, wherein a brake control a nominal value, a response threshold, or a control algorithm for the brake system is set or changed in dependence on the loss in tire pressure.

27. (New) Method as claimed in claim 26, further including changing a wheel specific nominal value for the wheel that has sustained a pressure loss.

28. (New) Method as claimed in claim 27, further including changing the nominal value for a wheel that has not lost wheel pressure.

29. (New) Method as claimed in claim 26, further including the step of changing the brake control nominal? Valve for all wheels if the wheel with a loss in pressure is unknown.

30. (New) Method as claimed in claim 25, further including the step of:

conducting a traction slip control maneuver wherein a nominal value, a response threshold, a control algorithm for the brake system, or the engine is set or changed in dependence on the tire pressure condition.

31. (New) Method as claimed in claim 25, further including the step of:

limiting the maximum speed of the vehicle by engine intervention when pressure loss is detected.

32. (New) Method as claimed in claim 25, further including the step of:

determining a test quantity from an input quantity for the purpose of pressure loss detection, wherein the input quantity is modified according to the driving dynamics variable.

33. (New) Method as claimed in claim 25, further including the step of:

determining a test quantity for pressure loss detection, wherein the test quantity is modified according to the driving dynamics variable.

34. (New) Method as claimed in claim 25, wherein the step of determining a loss of tire pressure remains undone when the vehicle parameters lie outside a predetermined range of parameter values.

35. (New) Method as claimed in claim 33, further including the step of:

determining a modification quantity during operation of the vehicle and storing said modification quantity in a non-volatile fashion.

36. (New) Device for controlling the driving dynamics sensor means for monitoring a vehicle parameter,

at least one controller connected between said sensor and an actuation means, wherein said actuation means is coupled to a vehicle component for effecting a change in the driving dynamics of the vehicle, and wherein said controller includes a pressure loss detection means for determining when said vehicle parameter is indicative of a loss of tire pressure.

37. (New) Device as claimed in claim 36, wherein the controller is a brake controller which sets or changes a nominal value, a response threshold, or a control algorithm for the brake system in dependence on the tire pressure condition.

38. (New) Device as claimed in claim 36, wherein the controller is a traction slip controller which sets or changes a nominal value, a response threshold, a control algorithm for the brake system, or the engine in dependence on the tire pressure condition.

39. (New) Device as claimed in claim 36, further including a modification device which influences the pressure loss detection in dependence on at least one driving dynamics variable.

40. (New) Device as claimed in claim 39, wherein the modification device operates in dependence on one or more of the following quantities: vehicle speed, longitudinal acceleration, yaw rate, transverse acceleration, steering angle, curve characteristic quantity, wheel acceleration, wheel slip, wheel slip gradient, tire torsion.

41. (New) Device as claimed in claim 39, wherein the determining device operates with respect to an input quantity, and wherein the modification device modifies the input quantity according to the driving dynamics variable.

42. (New) Device as claimed in claim 39, wherein the determining device determines a test quantity, and wherein the modification device modifies the test quantity according to the driving dynamics variable.

43. (New) Device as claimed in claim 39, wherein the modification device leaves the pressure loss detection undone when the driving dynamics variable lies outside a predetermined range of values.

44. (New) Device as claimed in claim 41, further including a non-volatile memory for storing a modification quantity which is determined during operation of the vehicle.

REMARKS

Prior to a formal examination of the above-identified application, acceptance of the new claims and the enclosed substitute specification (under 37 CFR 1.125) is respectfully requested. It is believed that the substitute specification and new claims will facilitate processing of the application in accordance with M.P.E.P. 608.01(q). The substitute specification and new claims are in compliance with 37 CFR 1.52 (a and b) and, while making no substantive changes, are submitted to conform this case to the formal requirements and long-established formal standards of U.S. Patent Office practice, and to provide improved idiom and better grammatical form.

The enclosed substitute specification is presented herein in both marked-up and clean versions.

STATEMENT

The undersigned, an attorney registered to practice before the office, hereby states that the enclosed substitute specification includes the same changes as are indicated in the mark-up copy of the original specification. The substitute specification contains no new subject matter.

Respectfully submitted,

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SUBSTITUTE SPECIFICATION: CLEAN COPY

09/937986
410 Rec'd PCT/PTO 03 OCT 2001

AP9610

Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

Technical Field

[0001] The present invention generally relates to vehicle control, and more particularly relates to a method and a device for pressure loss detection and for driving dynamics control.

Background of The Invention

[0002] In conventional pressure loss detection methods, one or more test quantities are determined with respect to most different signals, among these sensor signals and intermediate quantities from other vehicle components. The test quantities may e.g. be compared with threshold values to infer therefrom pressure conditions in the tires of the vehicle. Pressure loss detection can be effected individually for each wheel or for several or all wheels of the vehicle (for example, development of the quotient of the sum of the wheel speeds on the diagonal and comparison of the quotient with thresholds). Besides, tire pressure loss detection operations are usually based on a comparison between the vehicle speed (e.g. vehicle reference speed) and angular speeds (that can be detected by sensors) of the individual wheels. The relationship $w = v/r$ applies in this respect, wherein w designates the angular speed, v the vehicle speed (speed of the wheel axle), and r the dynamic tire-tread circumference which is smaller in tires with pressure loss than in regular tires.

[0003] Tire loss detection is affected by various disturbances, for example, by different running speeds of

wheels in cornering maneuvers (see e.g. Figure 3: the wheels 31, 34 of the vehicle 30 on the outside curve move by approximation on the radius Ra, while the wheels 32, 33 move on the smaller radius Ri so that they must cover a shorter distance in the same time and, hence, must cover less rotations). Other mechanisms which are caused by the driving dynamics of the vehicle will also lead to distortions (e.g. brake slip or traction slip, wrong signals when the vehicle is oversteered or understeered) so that inaccurate detections and especially faulty detections can occur.

[0004] It is partly possible to systematically compensate for errors by selecting the detection algorithm or by employing learned correction value tables. However, especially in high-dynamics driving maneuvers, this measure is not sufficient to prevent faulty detections with a sufficient rate of safety.

[0005] On the other hand, the tire pressure conditions also influence the quality of driving dynamics control systems such as anti-lock system, electronic stability control, traction slip control. The mentioned control systems mostly make use of the vehicle brakes, sometimes also the vehicle engine, as control elements and adjust there defined conditions, such as brake pressures, brake pressure gradients, wheel slip, engine output torque, etc., corresponding to the desired objective of the control. All these control interventions take place at least under the assumption that the force transmission between vehicle and wheel, on the one hand, and the roadway, on the other hand, is not disturbed at the vehicle end (at the roadway end it may e.g. be disturbed by slick ice). However, the above assumption is not correct when one or more tires of the vehicle suffer from pressure loss. Force transmission is

disturbed then, only lower forces can usually be transmitted. In the end, the result is that the mentioned regulation and control systems are wrongly conformed to the actual conditions. This is disadvantageous per se. In addition, unsymmetrical force transmissions may e.g. cause unexpected unstable driving conditions which is even dangerous.

[0006] An object of the present invention is to disclose a method and a device for pressure loss detection and for driving dynamics control which take into account the interactions between tire pressure and driving dynamics especially in driving maneuvers with a high driving dynamics.

[0007] Pressure loss detection according to the present invention operates as a function of at least one variable related to driving dynamics. When the driving dynamics variable satisfies determined conditions, pressure loss detection can be influenced according to predetermined patterns. Predetermined correction values or correction algorithms can be used to this end. 'Predetermined' in this context means that the values are correction values or correction strategies available from the very beginning (pre-determined) rather than values learned during operation of the vehicle. The correction values or correction strategies may be employed especially in driving maneuvers with a high driving dynamics, for example, when the longitudinal acceleration is > 0.1 g, preferably is > 0.2 g, and/or when the transverse acceleration is > 0.2 g or > 0.3 g, and/or when the wheel slip on at least one wheel is > 4 %, preferably is > 6 % (traction slip and brake slip).

[0008] One or more of the following quantities can be taken into account as driving dynamics variables: the vehicle speed, e.g. the vehicle reference speed as it is produced by defined algorithms from the wheel speeds, the longitudinal acceleration which is either determined from the vehicle reference speed by way of calculation or detected by sensors, the yaw rate (angular speed about the vertical axis), either detected by sensors or calculated, the transverse acceleration (detected by sensors or calculated), the steering wheel angle, in general a curve characteristic value (e.g. calculated curve radius), a wheel acceleration, especially a wheel angle acceleration as it can be derived from the wheel signals of the wheel sensors, for example, the wheel slip (difference between wheel (roadway) speed and vehicle reference speed), the wheel slip gradient (derivative of the wheel slip, wheel slip acceleration), the tire side wall torsion, e.g. detected by sensors.

[0009] One or more of the above quantities can be checked for the existence of defined conditions with respect to their values and also with respect to their time variation. When these conditions apply (value condition and, as the case may be, additionally time condition), modification of the pressure loss detection can occur.

[0010] Driving dynamics control according to the present invention also takes place in dependence on the tire pressure conditions found. The tire pressure conditions can affect the nominal values specification, the thresholds of response, or the selection of control strategies.

[0011] When the wheel suffering from the loss in pressure is known, modifications in the control strategy can be taken for this wheel only. In addition, modifications can be

effected in this case also on another wheel for the compensation of forces.

[0012] When the wheel suffering from pressure loss is unknown, modifications can be effected for all wheels.

[0013] In general, lower nominal pressure values, nominal pressure gradients, wheel slip values, or drive torques can be predetermined as nominal values or adjusted by the control in the event of pressure loss. The pressure loss detection for influencing the driving dynamics control can be performed as described hereinabove.

Brief Description of The Drawings

[0014] Figure 1 is an embodiment of the pressure loss detection according to the present invention.

[0015] Figure 2 is a more detailed embodiment of Figure 1.

[0016] Figure 3 is an explanation with respect to disturbances.

[0017] Figure 4 is a driving dynamics control system according to the present invention.

[0018] Figure 5 is a combined system made up of driving dynamics control and pressure loss detection.

Detailed Description of The Preferred Embodiments

[0019] Figure 1 shows a pressure loss detection device according to the present invention. The actual detection

takes place in the device 11 which may generally have a conventional operation. Pressure loss detection 11 receives input signals 13 and outputs output signals 15. Input signals 13 may comprise sensor signals, intermediate quantities from other vehicle components, and other data. Output signals 15 may comprise alarm signals, control signals for other device components, and information signals with respect to tire pressure. A test quantity PG can e.g. be determined as follows in the pressure loss detection:

$$PG = ((wvl + whr)/(wvr + whl)),$$

[0020] wherein wvl designates the left front wheel speed, wvr designates the right front wheel speed, whr the right rear wheel speed, and whl the left rear wheel speed. In the ideal case (constant velocity of all wheels, identical diameter of all wheels), the test quantity is 1, discrepancies herefrom may hint at a tire which is smaller due to the tire pressure and, hence, runs faster. The test quantity PG is compared to threshold values, and in the event that it exceeds or drops below the threshold values, a pressure loss is detected and appropriate signals are output.

[0021] Reference numeral 12 designates a modification device which receives input signals 14 that mirror one or more driving dynamics variables. Device 12, in turn, produces signals which permit influencing the pressure loss detection 11.

[0022] Pressure loss detection can be influenced in different ways. This is shown in more detail in Figure 2. The detection device 11 has a detection element 21 with a determining device 22 that determines a test quantity, for

example, as indicated hereinabove, and a checking device 25 which checks the test quantity by way of threshold values, represented by reference numeral 26. One or more signals are output when defined conditions prevail. The modification device 12 can have an effect on the detection in different ways. It can e.g. modify the input signals when pressure losses exist. This is represented by selector switches 23b, 23c and modification devices 24b, 24c which are actuated or set and adjusted according to the modification device 12.

[0023] The modification device 12 can also influence or change the algorithm used in the determining device 22. When e.g. traction slip prevails, provisions can be made that the test quantity is no longer determined with respect to the driven wheels, or that other values (e.g. those of the non-driven wheels) are used for the said wheels.

[0024] It is also possible to modify the test quantity itself, as it was determined by the determining device 22. This is indicated by selector switch 23a and modification device 24a that are actuated according to the modification device 12. It is also possible to prevent tire pressure testing at all. This is indicated by interruption of the output by means of switch 20 which is likewise actuated according to the modification device 12.

[0025] Besides, it is also possible to change a threshold value which is taken into account for the detection by e.g. writing a different value into the memory 26.

[0026] The mentioned measures can be employed individually and in combination with each other. In the modification device 12, there is a logic 29 which receives the driving dynamics data 14a-14d and, according to said, generates

suitable actuation signals for influencing the pressure loss detection according to one or more driving dynamics variables. The modification device 12 may also include a memory 28 which can comprise e.g. tables for correction values, wherein access is made to the tables according to a driving dynamics variable, and the read-out value is used for the correction of an input signal 13a, 13b or for the correction of the test quantity. The correction value can be used additively or multiplicatively, or as a replacement value. This way, input quantities 13a, 13b, intermediate quantities such as the test quantity PG, or threshold values can be changed, corrected, or replaced.

[0027] Pressure loss detection can also be rated so that method steps are permanently taken corresponding to a modification (with or without pressure loss), that, however, the modification is neutral (e.g. multiplication with 1, addition of 0) in the event of absence of pressure loss. This is advantageous because in the event of pressure loss, only the quantity used for correction rather than a corresponding algorithm must be changed in the case of pressure loss.

[0028] Beside the qualitative detection signals indicated in Figure 2, the determining device 22 can also produce data signals, for example, data representing the wheel diameter differences of the individual wheels. Said data, too, can be modified according to driving dynamics and output, as the case may be.

[0029] A side wall torsion sensor at the wheel tire furnishes a signal which is especially favorable for the present purposes. The result of acceleration and deceleration operations and lateral forces is that the side

wall of a tire displaces and twists in a circumferential direction and in a radial direction and, as the case may be, also in an axial direction of the wheel. This will occur to a particularly great extent in tires with pressure drop. When the side wall torsion is detected by sensors, this signal can be taken into account for determining the wheel dynamics and then indirectly for influencing the tire pressure detection, or it is taken into account directly for pressure loss detection, for example, when the torsion exceeds a certain degree.

[0030] Learning (i.e. adaptive) operations can also occur within the above-mentioned direct modification, for example, for determining correction values during operation of the vehicle which are adapted still better than factory-adjusted correction values. To store such learned correction values, memories can be provided which preserve any information inscribed in them, even in the event that their input voltage gets lost.

[0031] If driving dynamics sensors show redundancies, the signals with the highest resolution can be chosen.

[0032] In general, the input signals required and the output signals generated can be taken from a data bus or introduced into the bus, for example, a CAN bus. The driving dynamics variables employed may be sensor quantities, filtered sensor quantities, or data that is already preassessed.

[0033] Figure 4 shows a driving dynamics control according to the present invention comprising at least one controller 41 which receives input signals 43 and outputs output signals 45. Part of the input signals 43 will be measuring

signals from the controlled system (wheel sensors, acceleration sensor, transverse acceleration sensor, yaw rate sensor, steering angle sensor, or like sensors). Likewise, other input signals can be received, for example, quantities from other operations. A part of the output signals 45 will be actuation signals for control elements, for example, for the wheel brakes, hydraulic pumps, for an engine interface, or similar elements. The controller may represent a brake control, and/or a traction slip control, and/or an electronic stability control. The systems may operate a priori according to conventional algorithms.

[0034] Reference numeral 42 represents a pressure loss detection device which generally detects the existence of a pressure loss in a special wheel or in any wheel of the vehicle. The pressure loss detection 42 can be configured as described hereinabove.

[0035] The pressure loss detection 42 generates signals which modify the operation of the controller when pressure loss is detected. The modification can refer to the input quantities 43, the output quantities 45, or parameters or algorithms for processing the input data and for generating the output data.

[0036] When a wheel suffers from pressure loss, it is a priori desirable to load it less as far as acceleration forces and brake forces are concerned. Accordingly, it can be desirable to have lower brake forces or gradients hereof adjusted by the control for such a wheel. The same applies with respect to acceleration forces. To reach this aim, lower brake pressure values, or brake pressure gradients or engine torques, or engine torque gradients can be adjusted by the control.

[0037] Inasfar as the wheel with pressure loss is precisely known, this modified control can relate to the known wheel alone. For force compensation purposes, any other wheel, e.g. the diagonally opposite wheel, can also be controlled similarly in a modified fashion in this case. When the wheel with pressure loss is unknown, all wheels can be controlled in a modified fashion.

[0038] If a vehicle is equipped with an automatic transmission or (in all-wheel drive) a center clutch with automatic intervention, these control elements may also be used for driving dynamics control. When the pressure loss is detected, for example, clutches or lock differentials in the drive train of the corresponding wheel or the respective axle can be opened or only partly closed. This applies especially to the case of traction slip control.

[0039] It is particularly favorable when the driving dynamics control described hereinabove is integrated in conventional systems for cooperation. This means in particular that the system of the present invention does not act 'in competition' with conventional systems. Rather, it is advantageous that the driving dynamics control according to the present invention is integrated algorithmically in conventional control systems so that it can operate along with a conventional control by using the same hardware.

[0040] Figure 5 shows a combined embodiment of pressure loss detection and driving dynamics control. Like reference numerals as in the previously referenced drawings imply identical components which shall be explained herein again only as far as required. Among others, the controller 41 receives certain signals 15 from the pressure loss detection

11. The signals do not have to be exclusively signals output by the pressure loss detection 11.

[0041] The signal trains 13, 14, and 43 drawn separately in Figure 5 may comprise or designate the same signals, at least in part. This may also, at least in part, concern the access to a bus where the necessary data prevails, for example, cyclically.

AP9610

Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

Abstract of The Disclosure

In a method for pressure loss detection in the tire of a vehicle, the detection method operates in dependence on at least one driving dynamics variable. In a method for driving dynamics control, the driving dynamics is controlled also in dependence on a detected tire pressure loss.

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Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

Technical Field

The present invention generally relates to vehicle control, and more particularly relates to a method and a device for pressure loss detection and for driving dynamics control.

Background of The Invention

In conventional pressure loss detection methods, one or more test quantities are determined with respect to most different signals, among these sensor signals and intermediate quantities from other vehicle components. The test quantities may e.g. be compared with threshold values to infer therefrom pressure conditions in the tires of the vehicle. Pressure loss detection can be effected individually for each wheel or for several or all wheels of the vehicle (for example, development of the quotient of the sum of the wheel speeds on the diagonal and comparison of the quotient with thresholds). Besides, tire pressure loss detection operations are usually based on a comparison between the vehicle speed (e.g. vehicle reference speed) and angular speeds (that can be detected by sensors) of the individual wheels. The relationship $w = v/r$ applies in this respect, wherein w designates the angular speed, v the vehicle speed (speed of the wheel axle), and r the dynamic tire-tread circumference which is smaller in tires with pressure loss than in regular tires.

Tire loss detection is affected by various disturbances, for example, by different running speeds of wheels in cornering maneuvers (see e.g. Figure 3: the wheels 31, 34 of the vehicle

30 on the outside curve move by approximation on the radius Ra, while the wheels 32, 33 move on the smaller radius Ri so that they must cover a shorter distance in the same time and, hence, must cover less rotations). Other mechanisms which are caused by the driving dynamics of the vehicle will also lead to distortions (e.g. brake slip or traction slip, wrong signals when the vehicle is oversteered or understeered) so that inaccurate detections and especially faulty detections can occur.

It is partly possible to systematically compensate for errors by selecting the detection algorithm or by employing learned correction value tables. However, especially in high-dynamics driving maneuvers, this measure is not sufficient to prevent faulty detections with a sufficient rate of safety.

On the other hand, the tire pressure conditions also influence the quality of driving dynamics control systems such as anti-lock system, electronic stability control, traction slip control. The mentioned control systems mostly make use of the vehicle brakes, sometimes also the vehicle engine, as control elements and adjust there defined conditions, such as brake pressures, brake pressure gradients, wheel slip, engine output torque, etc., corresponding to the desired objective of the control. All these control interventions take place at least under the assumption that the force transmission between vehicle and wheel, on the one hand, and the roadway, on the other hand, is not disturbed at the vehicle end (at the roadway end it may e.g. be disturbed by slick ice). However, the above assumption is not correct when one or more tires of the vehicle suffer from pressure loss. Force transmission is disturbed then, only lower forces can usually be transmitted. In the end, the result is that the mentioned regulation and control systems are wrongly conformed to the actual

conditions. This is disadvantageous per se. In addition, unsymmetrical force transmissions may e.g. cause unexpected unstable driving conditions which is even dangerous.

An object of the present invention is to disclose a method and a device for pressure loss detection and for driving dynamics control which take into account the interactions between tire pressure and driving dynamics especially in driving maneuvers with a high driving dynamics.

[This object is achieved with the features of the independent claims. Dependent claims are directed to preferred embodiments of the present invention.]

Pressure loss detection according to the present invention operates as a function of at least one variable related to driving dynamics [variable]. When the driving dynamics variable satisfies determined conditions, pressure loss detection can be influenced according to predetermined patterns. Predetermined correction values or correction algorithms can be used to this end. 'Predetermined' in this context means that the values are correction values or correction strategies available from the very beginning (pre-determined) rather than values learned during operation of the vehicle. The correction values or correction strategies may be employed especially in driving maneuvers with a high driving dynamics, for example, when the longitudinal acceleration is > 0.1 g, preferably is > 0.2 g, and/or when the transverse acceleration is > 0.2 g or > 0.3 g, and/or when the wheel slip on at least one wheel is > 4 %, preferably is > 6 % (traction slip and brake slip).

One or more of the following quantities can be taken into account as driving dynamics variables: the vehicle speed, e.g.

the vehicle reference speed as it is produced by defined algorithms from the wheel speeds, the longitudinal acceleration which is either determined from the vehicle reference speed by way of calculation or detected by sensors, the yaw rate (angular speed about the vertical axis), either detected by sensors or calculated, the transverse acceleration (detected by sensors or calculated), the steering wheel angle, in general a curve characteristic value (e.g. calculated curve radius), a wheel acceleration, especially a wheel angle acceleration as it can be derived from the wheel signals of the wheel sensors, for example, the wheel slip (difference between wheel (roadway) speed and vehicle reference speed), the wheel slip gradient (derivative of the wheel slip, wheel slip acceleration), the tire side wall torsion, e.g. detected by sensors.

One or more of the above quantities can be checked for the existence of defined conditions with respect to their values and also with respect to their time variation. When these conditions apply (value condition and, as the case may be, additionally time condition), modification of the pressure loss detection can occur.

Driving dynamics control according to the present invention also takes place in dependence on the tire pressure conditions found. The tire pressure conditions can affect the nominal values specification, the thresholds of response, or the selection of control strategies.

When the wheel suffering from the loss in pressure is known, modifications in the control strategy can be taken for this wheel only. In addition, modifications can be effected in this case also on another wheel for the compensation of forces.

When the wheel suffering from pressure loss is unknown, modifications can be effected for all wheels.

In general, lower nominal pressure values, nominal pressure gradients, wheel slip values, or drive torques can be predetermined as nominal values or adjusted by the control in the event of pressure loss. The pressure loss detection for influencing the driving dynamics control can be performed as described hereinabove.

[Individual embodiments of the present invention will be described in the following by making reference to the accompanying drawings. In the drawings,]

Brief Description of The Drawings

Figure 1 is an embodiment of the pressure loss detection according to the present invention.

Figure 2 is a more detailed embodiment of Figure 1.

Figure 3 is an explanation with respect to disturbances.

Figure 4 is a driving dynamics control system according to the present invention.

Figure 5 is a combined system made up of driving dynamics control and pressure loss detection.

Detailed Description of The Preferred Embodiments

Figure 1 shows a pressure loss detection device according to the present invention. The actual detection takes place in the device 11 which may generally have a conventional operation.

Pressure loss detection 11 receives input signals 13 and outputs output signals 15. Input signals 13 may comprise sensor signals, intermediate quantities from other vehicle components, and other data. Output signals 15 may comprise alarm signals, control signals for other device components, and information signals with respect to tire pressure. A test quantity PG can e.g. be determined as follows in the pressure loss detection:

$$PG = ((wvl + whr)/(wvr + whl)),$$

wherein wvl designates the left front wheel speed, wvr designates the right front wheel speed, whr the right rear wheel speed, and whl the left rear wheel speed. In the ideal case (constant velocity of all wheels, identical diameter of all wheels), the test quantity is 1, discrepancies herefrom may hint at a tire which is smaller due to the tire pressure and, hence, runs faster. The test quantity PG is compared to threshold values, and in the event that it exceeds or drops below the threshold values, a pressure loss is detected and appropriate signals are output.

Reference numeral 12 designates a modification device which receives input signals 14 that mirror one or more driving dynamics variables. Device 12, in turn, produces signals which permit influencing the pressure loss detection 11.

Pressure loss detection can be influenced in [most] different ways. This is shown in more detail in Figure 2. The detection device 11 has a detection element 21 with a determining device 22 that determines a test quantity, for example, as indicated hereinabove, and a checking device 25 which checks the test quantity by way of threshold values, represented by reference numeral 26. One or more signals are output when defined

conditions prevail. The modification device 12 can have an effect on the detection in different ways. It can e.g. modify the input signals when pressure losses exist. This is represented by selector switches 23b, 23c and modification devices 24b, 24c which are actuated or set and adjusted according to the modification device 12.

The modification device 12 can also influence or change the algorithm used in the determining device 22. When e.g. traction slip prevails, provisions can be made that the test quantity is no longer determined with respect to the driven wheels, or that other values (e.g. those of the non-driven wheels) are used for the said wheels.

It is also possible to modify the test quantity itself, as it was determined by the determining device 22. This is indicated by selector switch 23a and modification device 24a that are actuated according to the modification device 12. It is also possible to prevent tire pressure testing at all. This is indicated by interruption of the output by means of switch 20 which is likewise actuated according to the modification device 12.

Besides, it is also possible to change a threshold value which is taken into account for the detection by e.g. writing a different value into the memory 26.

The mentioned measures can be employed individually and in combination with each other. In the modification device 12, there is a logic 29 which receives the driving dynamics data 14a-14d and, according to said, generates suitable actuation signals for influencing the pressure loss detection according to one or more driving dynamics variables. The modification device 12 may also include a memory 28 which can comprise e.g.

tables for correction values, wherein access is made to the tables according to a driving dynamics variable, and the read-out value is used for the correction of an input signal 13a, 13b or for the correction of the test quantity. The correction value can be used additively or multiplicatively, or as a replacement value. This way, input quantities 13a, 13b, intermediate quantities such as the test quantity PG, or threshold values can be changed, corrected, or replaced.

Pressure loss detection can also be rated so that method steps are permanently taken corresponding to a modification (with or without pressure loss), that, however, the modification is neutral (e.g. multiplication with 1, addition of 0) in the event of absence of pressure loss. This is advantageous because in the event of pressure loss, only the quantity used for correction rather than a corresponding algorithm must be changed in the case of pressure loss.

Beside the qualitative detection signals indicated in Figure 2, the determining device 22 can also produce data signals, for example, data representing the wheel diameter differences of the individual wheels. Said data, too, can be modified according to driving dynamics and output, as the case may be.

A side wall torsion sensor at the wheel tire furnishes a signal which is especially favorable for the present purposes. The result of acceleration and deceleration operations and lateral forces is that the side wall of a tire displaces and twists in a circumferential direction and in a radial direction and, as the case may be, also in an axial direction of the wheel. This will occur to a particularly great extent in tires with pressure drop. When the side wall torsion is detected by sensors, this signal can be taken into account for determining the wheel dynamics and then indirectly for

influencing the tire pressure detection, or it is taken into account directly for pressure loss detection, for example, when the torsion exceeds a certain degree.

Learning (i.e. adaptive) operations can also occur within the above-mentioned direct modification, for example, for determining correction values during operation of the vehicle which are adapted still better than factory-adjusted correction values. To store such learned correction values, memories can be provided which preserve any information inscribed in them, even in the event that their input voltage gets lost.

If driving dynamics sensors show redundancies, the signals with the highest resolution can be chosen.

In general, the input signals required and the output signals generated can be taken from a data bus or introduced into the bus, for example, a CAN bus. The driving dynamics variables employed may be sensor quantities, filtered sensor quantities, or data that is already preassessed.

Figure 4 shows a driving dynamics control according to the present invention comprising at least one controller 41 which receives input signals 43 and outputs output signals 45. Part of the input signals 43 will be measuring signals from the controlled system (wheel sensors, acceleration sensor, transverse acceleration sensor, yaw rate sensor, steering angle sensor, or like sensors). Likewise, other input signals can be received, for example, quantities from other operations. A part of the output signals 45 will be actuation signals for control elements, for example, for the wheel brakes, hydraulic pumps, for an engine interface, or similar elements. The controller may represent a brake control, and/or

a traction slip control, and/or an electronic stability control. The systems may operate a priori according to conventional algorithms.

Reference numeral 42 represents a pressure loss detection device which generally detects the existence of a pressure loss in a special wheel or in any wheel of the vehicle. The pressure loss detection 42 can be configured as described hereinabove.

The pressure loss detection 42 generates signals which modify the operation of the controller when pressure loss is detected. The modification can refer to the input quantities 43, the output quantities 45, or parameters or algorithms for processing the input data and for generating the output data.

When a wheel suffers from pressure loss, it is a priori desirable to load it less as far as acceleration forces and brake forces are concerned. Accordingly, it can be desirable to have lower brake forces or gradients hereof adjusted by the control for such a wheel. The same applies with respect to acceleration forces. To reach this aim, lower brake pressure values, or brake pressure gradients or engine torques, or engine torque gradients can be adjusted by the control.

Inasfar as the wheel with pressure loss is precisely known, this modified control can relate to the known wheel alone. For force compensation purposes, any other wheel, e.g. the diagonally opposite wheel, can also be controlled similarly in a modified fashion in this case. When the wheel with pressure loss is unknown, all wheels can be controlled in a modified fashion.

If a vehicle is equipped with an automatic transmission or (in all-wheel drive) a center clutch with automatic intervention, these control elements may also be used for driving dynamics control. When the pressure loss is detected, for example, clutches or lock differentials in the drive train of the corresponding wheel or the respective axle can be opened or only partly closed. This applies especially to the case of traction slip control.

It is particularly favorable when the driving dynamics control described hereinabove is integrated in conventional systems for cooperation. This means in particular that the system of the present invention does not act 'in competition' with conventional systems. Rather, it is advantageous that the driving dynamics control according to the present invention is integrated algorithmically in conventional control systems so that it can operate along with a conventional control by using the same hardware.

Figure 5 shows a combined embodiment of pressure loss detection and driving dynamics control. Like reference numerals as in the previously referenced drawings imply identical components which shall be explained herein again only as far as required. Among others, the controller 41 receives certain signals 15 from the pressure loss detection 11. The signals do not have to be exclusively signals output by the pressure loss detection 11.

The signal trains 13, 14, and 43 drawn separately in Figure 5 may comprise or designate the same signals, at least in part. This may also, at least in part, concern the access to a bus where the necessary data prevails, for example, cyclically.

AP9610

[Abstract:]

Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

Abstract of The Disclosure

In a method for pressure loss detection in the tire of a vehicle, the detection method operates in dependence on at least one driving dynamics variable. In a method for driving dynamics control, the driving dynamics is controlled also in dependence on a detected tire pressure loss.

[(Figure 5)]

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Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

The present invention relates to a method and a device for pressure loss detection and for driving dynamics control.

In conventional pressure loss detection methods, one or more test quantities are determined with respect to most different signals, among these sensor signals and intermediate quantities from other vehicle components. The test quantities may e.g. be compared with threshold values to infer therefrom pressure conditions in the tires of the vehicle. Pressure loss detection can be effected individually for each wheel or for several or all wheels of the vehicle (for example, development of the quotient of the sum of the wheel speeds on the diagonal and comparison of the quotient with thresholds). Besides, tire pressure loss detection operations are usually based on a comparison between the vehicle speed (e.g. vehicle reference speed) and angular speeds (that can be detected by sensors) of the individual wheels. The relationship w = v/r applies in this respect, wherein w designates the angular speed, v the vehicle speed (speed of the wheel axle), and r the dynamic tire-tread circumference which is smaller in tires with pressure loss than in regular tires.

Tire loss detection is affected by various disturbances, for example, by different running speeds of wheels in cornering maneuvers (see e.g. Figure 3: the wheels 31, 34 of the vehicle 30 on the outside curve move by approximation on the radius Ra, while the wheels 32, 33 move on the smaller radius Ri so that they must cover a shorter distance in the same time and, hence, must cover less rotations). Other mechanisms which are caused

by the driving dynamics of the vehicle will also lead to distortions (e.g. brake slip or traction slip, wrong signals when the vehicle is oversteered or understeered) so that inaccurate detections and especially faulty detections can occur.

It is partly possible to systematically compensate for errors by selecting the detection algorithm or by employing learned correction value tables. However, especially in high-dynamics driving maneuvers, this measure is not sufficient to prevent faulty detections with a sufficient rate of safety.

On the other hand, the tire pressure conditions also influence the quality of driving dynamics control systems such as anti-lock system, electronic stability control, traction slip control. The mentioned control systems mostly make use of the vehicle brakes, sometimes also the vehicle engine, as control elements and adjust there defined conditions, such as brake pressures, brake pressure gradients, wheel slip, engine output torque, etc., corresponding to the desired objective of the control. All these control interventions take place at least under the assumption that the force transmission between vehicle and wheel, on the one hand, and the roadway, on the other hand, is not disturbed at the vehicle end (at the roadway end it may e.g. be disturbed by slick ice). However, the above assumption is not correct when one or more tires of the vehicle suffer from pressure loss. Force transmission is disturbed then, only lower forces can usually be transmitted. In the end, the result is that the mentioned regulation and control systems are wrongly conformed to the actual conditions. This is disadvantageous per se. In addition, unsymmetrical force transmissions may e.g. cause unexpected unstable driving conditions which is even dangerous.

An object of the present invention is to disclose a method and a device for pressure loss detection and for driving dynamics control which take into account the interactions between tire pressure and driving dynamics especially in driving maneuvers with a high driving dynamics.

This object is achieved with the features of the independent claims. Dependent claims are directed to preferred embodiments of the present invention.

Pressure loss detection according to the present invention operates as a function of at least one driving dynamics variable. When the driving dynamics variable satisfies determined conditions, pressure loss detection can be influenced according to predetermined patterns. Predetermined correction values or correction algorithms can be used to this end. 'Predetermined' in this context means that the values are correction values or correction strategies available from the very beginning rather than values learned during operation of the vehicle. The correction values or correction strategies may be employed especially in driving maneuvers with a high driving dynamics, for example, when the longitudinal acceleration is > 0.1 g, preferably is > 0.2 g, and/or when the transverse acceleration is > 0.2 g or > 0.3 g, and/or when the wheel slip on at least one wheel is > 4 %, preferably is > 6 % (traction slip and brake slip).

One or more of the following quantities can be taken into account as driving dynamics variables: the vehicle speed, e.g. the vehicle reference speed as it is produced by defined algorithms from the wheel speeds, the longitudinal acceleration which is either determined from the vehicle reference speed by way of calculation or detected by sensors, the yaw rate (angular speed about the vertical axis), either detected by

sensors or calculated, the transverse acceleration (detected by sensors or calculated), the steering wheel angle, in general a curve characteristic value (e.g. calculated curve radius), a wheel acceleration, especially a wheel angle acceleration as it can be derived from the wheel signals of the wheel sensors, for example, the wheel slip (difference between wheel (roadway) speed and vehicle reference speed), the wheel slip gradient (derivative of the wheel slip, wheel slip acceleration), the tire side wall torsion, e.g. detected by sensors.

One or more of the above quantities can be checked for the existence of defined conditions with respect to their values and also with respect to their time variation. When these conditions apply (value condition and, as the case may be, additionally time condition), modification of the pressure loss detection can occur.

Driving dynamics control according to the present invention also takes place in dependence on the tire pressure conditions found. The tire pressure conditions can affect the nominal values specification, the thresholds of response, or the selection of control strategies.

When the wheel suffering from the loss in pressure is known, modifications in the control strategy can be taken for this wheel only. In addition, modifications can be effected in this case also on another wheel for the compensation of forces.

When the wheel suffering from pressure loss is unknown, modifications can be effected for all wheels.

In general, lower nominal pressure values, nominal pressure gradients, wheel slip values, or drive torques can be predetermined as nominal values or adjusted by the control in

the event of pressure loss. The pressure loss detection for influencing the driving dynamics control can be performed as described hereinabove.

Individual embodiments of the present invention will be described in the following by making reference to the accompanying drawings. In the drawings,

Figure 1 is an embodiment of the pressure loss detection according to the present invention.

Figure 2 is a more detailed embodiment of Figure 1.

Figure 3 is an explanation with respect to disturbances.

Figure 4 is a driving dynamics control system according to the present invention.

Figure 5 is a combined system made up of driving dynamics control and pressure loss detection.

Figure 1 shows a pressure loss detection device according to the present invention. The actual detection takes place in the device 11 which may generally have a conventional operation. Pressure loss detection 11 receives input signals 13 and outputs output signals 15. Input signals 13 may comprise sensor signals, intermediate quantities from other vehicle components, and other data. Output signals 15 may comprise alarm signals, control signals for other device components, and information signals with respect to tire pressure. A test quantity PG can e.g. be determined as follows in the pressure loss detection:

$$PG = ((wvl + whr)/(wvr + whl)),$$

wherein wvl designates the left front wheel speed, wvr designates the right front wheel speed, whr the right rear wheel speed, and whl the left rear wheel speed. In the ideal case (constant velocity of all wheels, identical diameter of all wheels), the test quantity is 1, discrepancies herefrom may hint at a tire which is smaller due to the tire pressure and, hence, runs faster. The test quantity PG is compared to threshold values, and in the event that it exceeds or drops below the threshold values, a pressure loss is detected and appropriate signals are output.

Reference numeral 12 designates a modification device which receives input signals 14 that mirror one or more driving dynamics variables. Device 12, in turn, produces signals which permit influencing the pressure loss detection 11.

Pressure loss detection can be influenced in most different ways. This is shown in more detail in Figure 2. The detection device 11 has a detection element 21 with a determining device 22 that determines a test quantity, for example, as indicated hereinabove, and a checking device 25 which checks the test quantity by way of threshold values, represented by reference numeral 26. One or more signals are output when defined conditions prevail. The modification device 12 can have an effect on the detection in different ways. It can e.g. modify the input signals when pressure losses exist. This is represented by selector switches 23b, 23c and modification devices 24b, 24c which are actuated or set and adjusted according to the modification device 12.

The modification device 12 can also influence or change the algorithm used in the determining device 22. When e.g. traction slip prevails, provisions can be made that the test quantity is no longer determined with respect to the driven wheels, or that

other values (e.g. those of the non-driven wheels) are used for the said wheels.

It is also possible to modify the test quantity itself, as it was determined by the determining device 22. This is indicated by selector switch 23a and modification device 24a that are actuated according to the modification device 12. It is also possible to prevent tire pressure testing at all. This is indicated by interruption of the output by means of switch 20 which is likewise actuated according to the modification device 12.

Besides, it is also possible to change a threshold value which is taken into account for the detection by e.g. writing a different value into the memory 26.

The mentioned measures can be employed individually and in combination with each other. In the modification device 12, there is a logic 29 which receives the driving dynamics data 14a-14d and, according to said, generates suitable actuation signals for influencing the pressure loss detection according to one or more driving dynamics variables. The modification device 12 may also include a memory 28 which can comprise e.g. tables for correction values, wherein access is made to the tables according to a driving dynamics variable, and the read-out value is used for the correction of an input signal 13a, 13b or for the correction of the test quantity. The correction value can be used additively or multiplicatively, or as a replacement value. This way, input quantities 13a, 13b, intermediate quantities such as the test quantity PG, or threshold values can be changed, corrected, or replaced.

Pressure loss detection can also be rated so that method steps are permanently taken corresponding to a modification (with or

without pressure loss), that, however, the modification is neutral (e.g. multiplication with 1, addition of 0) in the event of absence of pressure loss. This is advantageous because in the event of pressure loss, only the quantity used for correction rather than a corresponding algorithm must be changed in the case of pressure loss.

Beside the qualitative detection signals indicated in Figure 2, the determining device 22 can also produce data signals, for example, data representing the wheel diameter differences of the individual wheels. Said data, too, can be modified according to driving dynamics and output, as the case may be.

A side wall torsion sensor at the wheel tire furnishes a signal which is especially favorable for the present purposes. The result of acceleration and deceleration operations and lateral forces is that the side wall of a tire displaces and twists in a circumferential direction and in a radial direction and, as the case may be, also in an axial direction of the wheel. This will occur to a particularly great extent in tires with pressure drop. When the side wall torsion is detected by sensors, this signal can be taken into account for determining the wheel dynamics and then indirectly for influencing the tire pressure detection, or it is taken into account directly for pressure loss detection, for example, when the torsion exceeds a certain degree.

Learning operations can also occur within the above-mentioned direct modification, for example, for determining correction values during operation of the vehicle which are adapted still better than factory-adjusted correction values. To store such learned correction values, memories can be provided which preserve any information inscribed in them, even in the event that their input voltage gets lost.

If driving dynamics sensors show redundancies, the signals with the highest resolution can be chosen.

In general, the input signals required and the output signals generated can be taken from a data bus or introduced into the bus, for example, a CAN bus. The driving dynamics variables employed may be sensor quantities, filtered sensor quantities, or data that is already preassessed.

Figure 4 shows a driving dynamics control according to the present invention comprising at least one controller 41 which receives input signals 43 and outputs output signals 45. Part of the input signals 43 will be measuring signals from the controlled system (wheel sensors, acceleration sensor, transverse acceleration sensor, yaw rate sensor, steering angle sensor, or like sensors). Likewise, other input signals can be received, for example, quantities from other operations. A part of the output signals 45 will be actuation signals for control elements, for example, for the wheel brakes, hydraulic pumps, for an engine interface, or similar elements. The controller may represent a brake control, and/or a traction slip control, and/or an electronic stability control. The systems may operate a priori according to conventional algorithms.

Reference numeral 42 represents a pressure loss detection device which generally detects the existence of a pressure loss in a special wheel or in any wheel of the vehicle. The pressure loss detection 42 can be configured as described hereinabove.

The pressure loss detection 42 generates signals which modify the operation of the controller when pressure loss is detected. The modification can refer to the input quantities 43, the

output quantities 45, or parameters or algorithms for processing the input data and for generating the output data.

When a wheel suffers from pressure loss, it is a priori desirable to load it less as far as acceleration forces and brake forces are concerned. Accordingly, it can be desirable to have lower brake forces or gradients hereof adjusted by the control for such a wheel. The same applies with respect to acceleration forces. To reach this aim, lower brake pressure values, or brake pressure gradients or engine torques, or engine torque gradients can be adjusted by the control.

Inasfar as the wheel with pressure loss is precisely known, this modified control can relate to the known wheel alone. For force compensation purposes, any other wheel, e.g. the diagonally opposite wheel, can also be controlled similarly in a modified fashion in this case. When the wheel with pressure loss is unknown, all wheels can be controlled in a modified fashion.

If a vehicle is equipped with an automatic transmission or (in all-wheel drive) a center clutch with automatic intervention, these control elements may also be used for driving dynamics control. When the pressure loss is detected, for example, clutches or lock differentials in the drive train of the corresponding wheel or the respective axle can be opened or only partly closed. This applies especially to the case of traction slip control.

It is particularly favorable when the driving dynamics control described hereinabove is integrated in conventional systems for cooperation. This means in particular that the system of the present invention does not act 'in competition' with conventional systems. Rather, it is advantageous that the

driving dynamics control according to the present invention is integrated algorithmically in conventional control systems so that it can operate along with a conventional control by using the same hardware.

Figure 5 shows a combined embodiment of pressure loss detection and driving dynamics control. Like reference numerals as in the previously referenced drawings imply identical components which shall--be explained herein again only as far as required. Among others, the controller 41 receives certain signals 15 from the pressure loss detection 11. The signals do not have to be exclusively signals output by the pressure loss detection 11.

The signal trains 13, 14, and 43 drawn separately in Figure 5 may comprise or designate the same signals, at least in part. This may also, at least in part, concern the access to a bus where the necessary data prevails, for example, cyclically.

Patent Claims:

1. Method for identifying a drop in pressure in the tire of a vehicle,
   c h a r a c t e r i z e d in that the detection method operates in dependence on at least one driving dynamics variable.

2. Method as claimed in claim 2,
   c h a r a c t e r i z e d in that driving dynamics comprises one or more of the following variables: vehicle speed, longitudinal acceleration, yaw rate, transverse acceleration, steering angle, curve characteristic quantity, wheel acceleration, wheel slip, wheel slip gradient, tire torsion.

3. Method as claimed in claim 1 or 2, wherein a test quantity is determined from an input quantity for the purpose of pressure loss detection,
   c h a r a c t e r i z e d in that the input quantity is modified according to the driving dynamics variable.

4. Method as claimed in claim 1 or 2, wherein a test quantity is determined for pressure loss detection,
   c h a r a c t e r i z e d in that the test quantity is modified according to the driving dynamics variable.

5. Method as claimed in any one of the preceding claims,
   c h a r a c t e r i z e d in that pressure loss detection remains undone when the driving dynamics variable lies outside a predetermined range of values.

6. Method as claimed in claim 3 or 4, c h a r a c t e r i z e d in that a modification quantity is determined during operation of the vehicle and stored in a non-volatile fashion.

7. Device for identifying a drop in pressure in the tire of a vehicle, in particular for implementing the method as claimed in any one of the preceding claims, including a detection device (11) for pressure loss detection, c h a r a c t e r i z e d by a modification device (12, 20, 23, 24) which influences the pressure loss detection in dependence on at least one driving dynamics variable.

8. Device as claimed in claim 7, c h a r a c t e r i z e d in that the modification device operates in dependence on one or more of the following quantities: vehicle speed, longitudinal acceleration, yaw rate, transverse acceleration, steering angle, curve characteristic quantity, wheel acceleration, wheel slip, wheel slip gradient, tire torsion.

9. Device as claimed in claim 7 or 8, wherein the determining device operates with respect to an input quantity, c h a r a c t e r i z e d in that the modification device (23b,c, 24b,c) modifies the input quantity according to the driving dynamics variable.

10. Device as claimed in any one of claims 7 to 9, wherein the determining device determines a test quantity, c h a r a c t e r i z e d in that the modification device (23a, 24a) modifies the test quantity according to the driving dynamics variable.

11. Device as claimed in any one of claims 7 to 10, characterized in that the modification device (20) leaves the pressure loss detection undone when the driving dynamics variable lies outside a predetermined range of values.

12. Device as claimed in claim 9 or 10, characterized by a non-volatile memory (28) for storing a modification quantity which is determined during operation of the vehicle.

13. Method for driving dynamics control, characterized in that the control of driving dynamics is also effected in dependence on a tire pressure loss detected.

14. Method as claimed in claim 13, characterized in that in brake control a nominal value, and/or a response threshold, and/or a control algorithm for the brake system is set or changed in dependence on the loss in tire pressure.

15. Method as claimed in claim 14, characterized in that when the wheel with pressure loss is known, a nominal value for this wheel is changed.

16. Method as claimed in claim 15, characterized in that a nominal value is changed for another wheel without pressure loss.

17. Method as claimed in any one of claims 14 to 16, c h a r a c t e r i z e d in that when the wheel with a loss in pressure is unknown, a nominal value is changed for all wheels.

18. Method as claimed in claims 13 to 17, c h a r a c t e r i z e d in that in traction slip control a nominal value, and/or a response threshold, and/or a control algorithm for the brake system, and/or the engine is set or changed in dependence on the tire pressure condition.

19. Method as claimed in any one of claims 13 to 18, c h a r a c t e r i z e d in that the maximum speed of the vehicle is limited by engine intervention when pressure loss is detected.

20. Method as claimed in any one of claims 13 to 19, c h a r a c t e r i z e d in that tire pressure loss detection is performed by implementing a method as claimed in any one of claims 1 to 6.

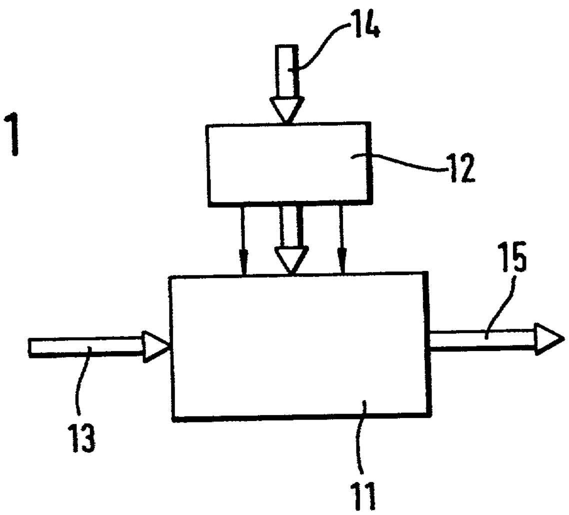
21. Device for driving dynamics control with sensor means, at least one controller (41), actuation means, and a pressure loss detection device (42), in particular for implementing the method as claimed in any one of claims 13 to 20, c h a r a c t e r i z e d in that the controller controls the driving dynamics also in dependence on a tire pressure condition determined by the pressure loss detection device.

22. Device as claimed in claim 21, characterized in that the controller is a brake controller which sets or changes a nominal value, and/or a response threshold, and/or a control algorithm for the brake system in dependence on the tire pressure condition.

23. Device as claimed in claim 21 or 22, characterized in that the controller is a traction slip controller which sets or changes a nominal value, and/or a response threshold, and/or a control algorithm for the brake system, and/or the engine in dependence on the tire pressure condition.

24. Device as claimed in any one of claims 21 to 27, characterized in that the pressure loss detection device (42) is configured according to any one of claims 7 to 12.

Fig. 1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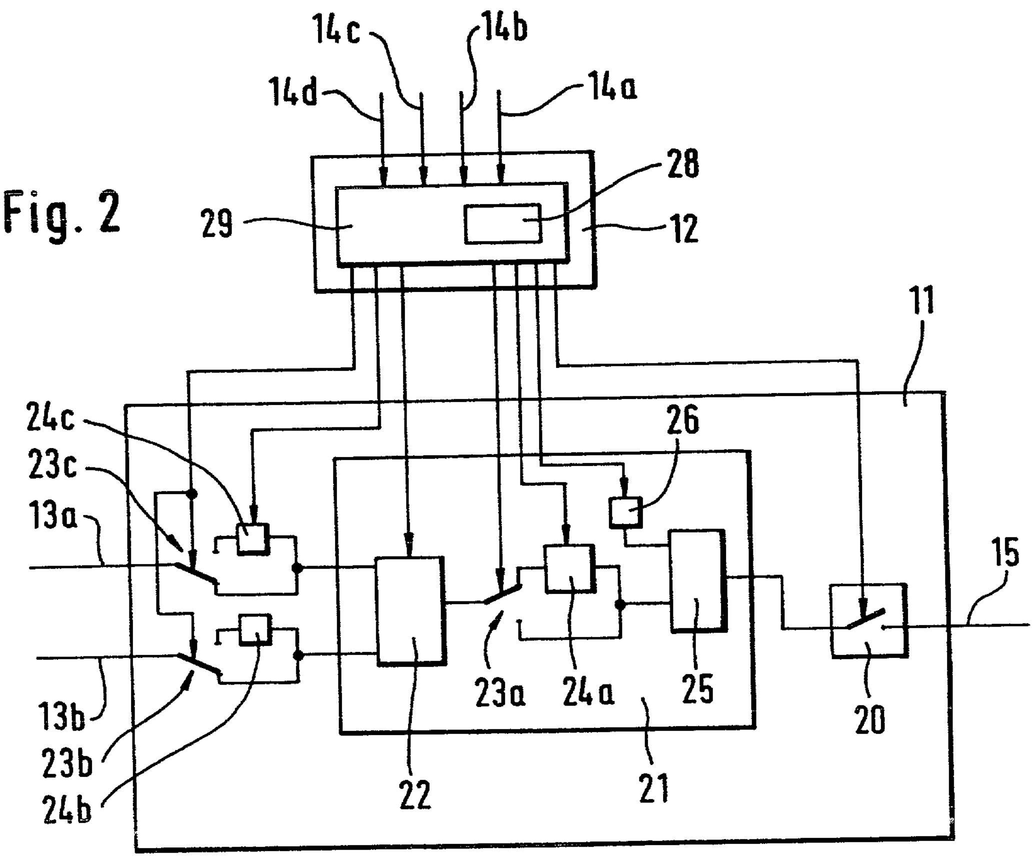
12
15
13
11

Fig. 2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22
21

Fig. 3

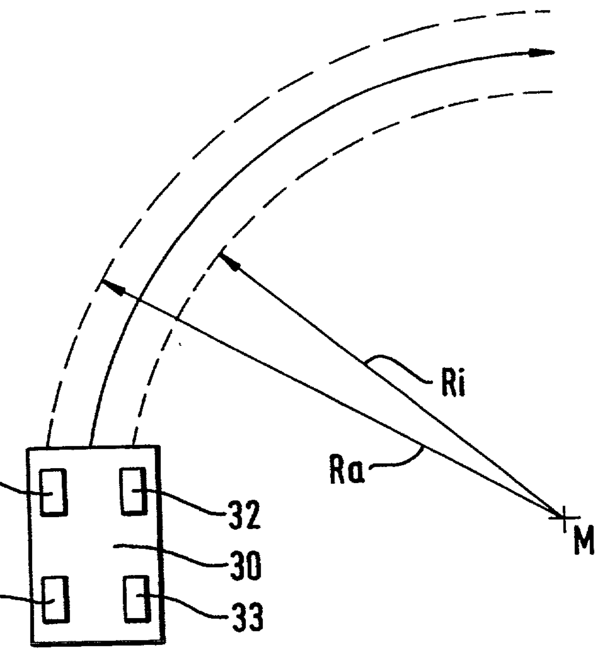


Fig. 4

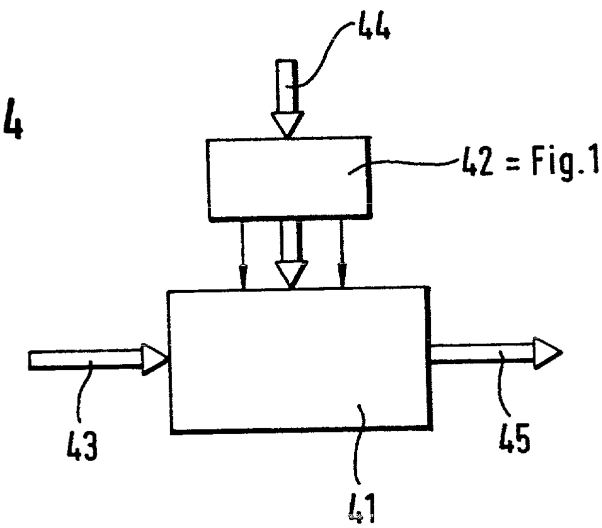
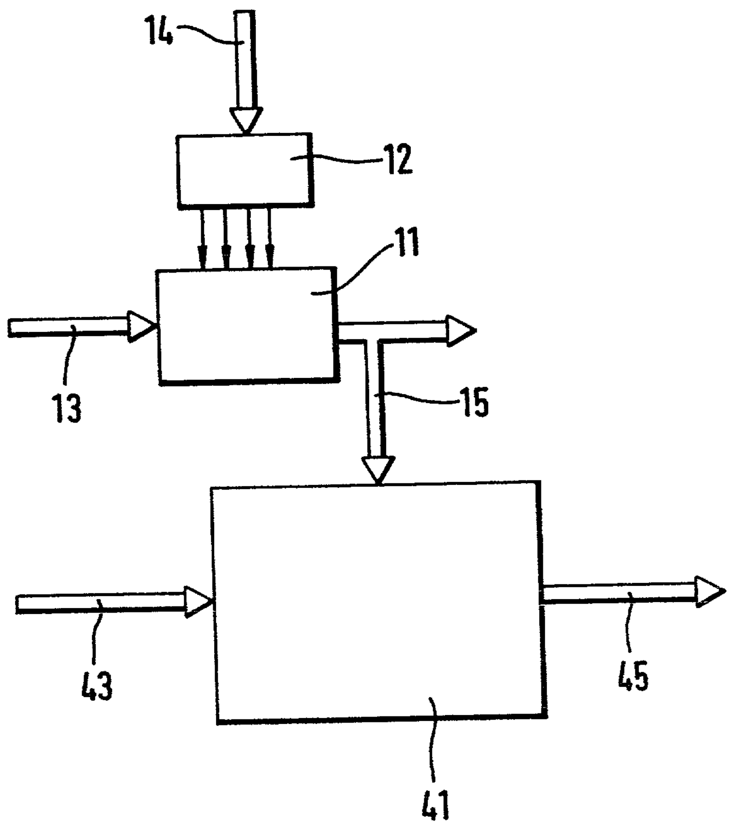


Fig. 5



PTO/SB/103 (8-96)
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Patent and Trademark Office: U.S DEPARTMENT OF COMMERCE

Declaration and Power of Attorney for Patent Application
Erklärung für Patentanmeldungen mit Vollmacht

German Language Declaration

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As a below named inventor, I hereby declare that:

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My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Method and Device for Identifying a Drop in Pressure and for Controlling Dynamics of Vehicle Movement

deren Beschreibung hier beigefügt ist, es sei denn (in diesem Falle Zutreffendes bitte ankreuzen), diese Erfindung

the specification of which is attached hereto unless the following box is checked:

wurde angemeldet am
unter der US-Anmeldenummer oder unter der Internationalen Anmeldenummer im Rahmen des Vertrags über die Zusammenarbeit auf dem Gebiet des Patentwesens (PCT).

was filed on **29/March/2000**
as United States Application Number or PCT International Application Number
PCT/EP00/02741

Ich bestätige hiermit, daß ich den Inhalt der oben angegebenen Patentanmeldung, einschließlich der Ansprüche, die durch einen oben erwähnten Zusatzantrag und in einem "preliminary amendment" abgeändert wurden, durchgesehen und verstanden habe.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above and as amended in a preliminary amendment.

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Prior Foreign Applications
(Fruhere ausländische Anmeldungen)

Priority Not Claimed
Priorität nicht beansprucht

Number	Country	Day/Month/Year Filed
199 15 233.0	**Germany**	**3/April/1999**
199 15 231.4	**Germany**	**3/April/1999**
199 61 681.7	**Germany**	**21/December/1999**

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I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s)listed below.

Application No. , filed on

Application No. , filed on

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Application No , filed on — Status: patented/pending/abandoned)

Application No , filed on — Status: patented/pending/abandoned

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Attorney's Docket No: AP9610

g:PATENT/Formal matters/R0124282 DOC

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THIRD NAMED INVENTOR	**FOURTH NAMED INVENTOR**
Signature Date **P.O. ADDRESS and RESIDENCE** **Citizen of**	Signature Date **P.O. ADDRESS and RESIDENCE** **Citizen of**

If box is checked, subsequent inventors are listed on a separate sheet

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